

Fluid Condition Monitoring System Results of Evaluation on FOKKER 100 Aircraft In Scandinavia



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FAA / JAA / TC In-Flight / Ground De-Icing
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INTERTECHNIQUE

SAE TYPE IV FLUID HOLDOVER GUIDELINES

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
°C	°F		Frost ²	Freezing Fog	Snow	Freezing Drizzle ⁴	Light Freezing Rain	Rain on Cold Soaked Wing	Other ⁵	
above 0	above 32	100/0	18:00	1:05 - 2:15	0:35 - 1:05	0:40 - 1:10	0:25 - 0:40	0:10 - 0:50	CAUTION: No holdover time guidelines exist	
		75/25	6:00	1:05 - 1:45	0:30 - 1:05	0:35 - 0:50	0:15 - 0:30	0:05 - 0:35		
		50/50	4:00	0:15 - 0:35	0:05 - 0:20	0:10 - 0:20	0:05 - 0:10			
0 to -3	32 to 27	100/0	12:00	1:05 - 2:15	0:30 - 0:55	0:40 - 1:10	0:25 - 0:40			
		75/25	5:00	1:05 - 1:45	0:25 - 0:50	0:35 - 0:50	0:15 - 0:30			
		50/50	3:00	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10			
below -3 to -14	below 27 to 7	100/0	12:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45 ³	0:10 - 0:25 ³			
		75/25	5:00	0:25 - 0:50	0:15 - 0:25	0:15 - 0:30 ³	0:10 - 0:20 ³			
below -14 to -25	below 7 to -13	100/0	12:00	0:15 - 0:40	0:15 - 0:30					
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.							

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside Air Temperature Vol = Volume

NOTES

- ¹ Based on tests of neat fluids with the lowest viscosity deliverable on the aircraft, yet meeting Type IV WSET and HHET.
- ² During conditions that apply to aircraft protection for ACTIVE FROST.
- ³ The lowest use temperature is limited to -10°C (14°F).
- ⁴ Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- ⁵ Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

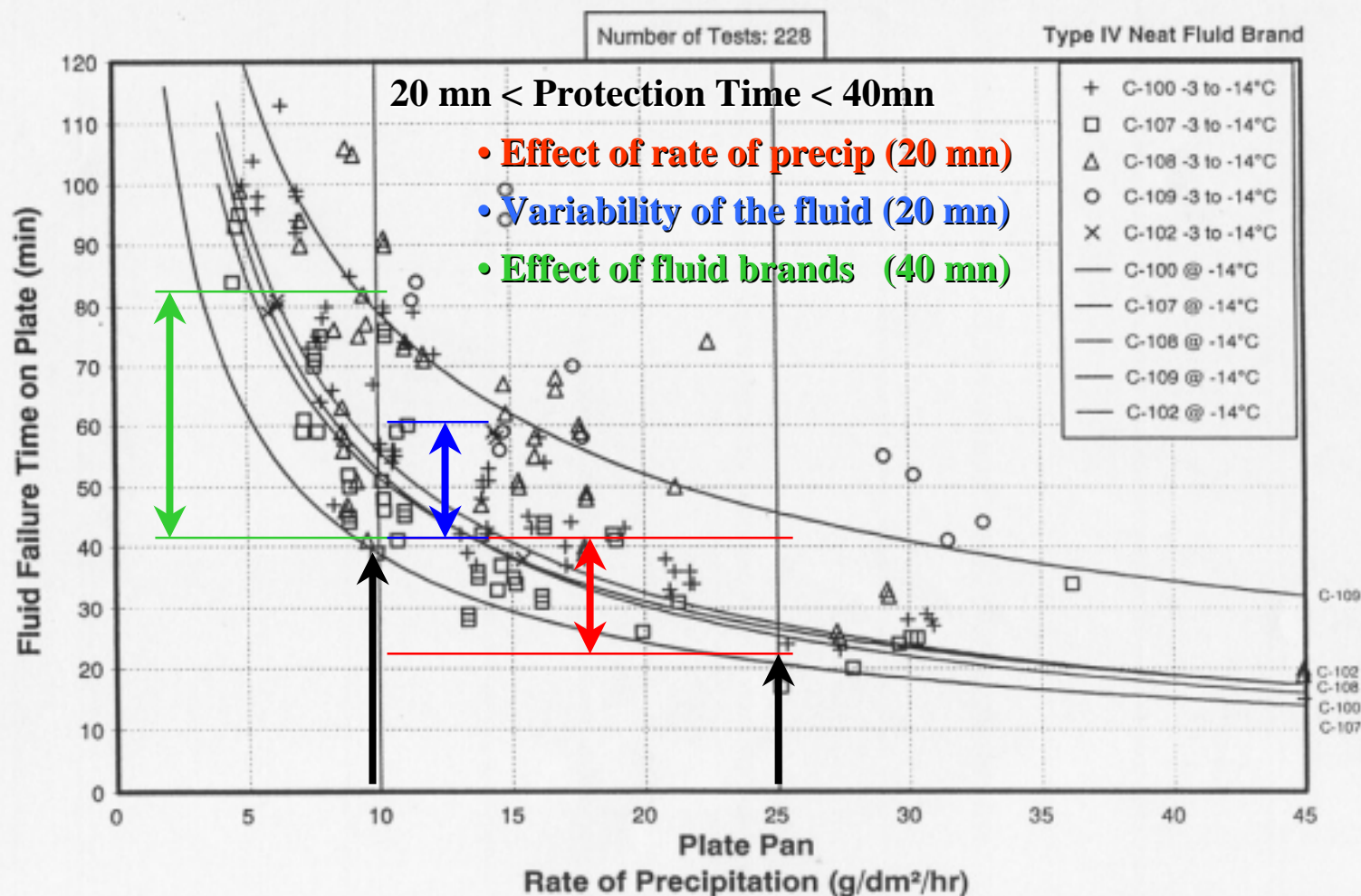
CAUTIONS

- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT.
- The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
- Fluids used during ground deicing do not provide ice protection during flight.



Anti-Icing Fluid Protection time variability

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT (-3 to -14°C)
NATURAL SNOW CONDITIONS



Fluid Condition Monitoring System

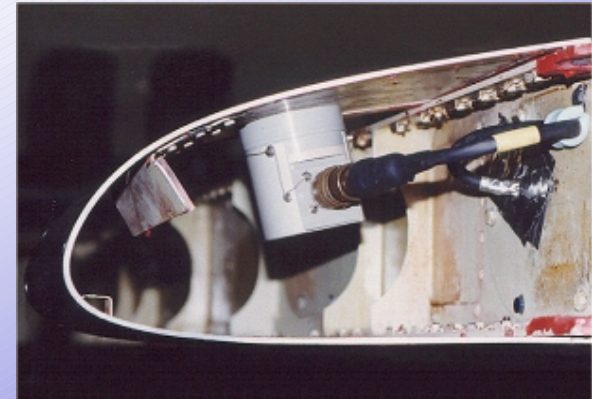
■ INTERTECHNIQUE's Ultrasonic Technology :

- Glycol based anti-icing fluid characteristics; concentration, thickness.
- Detection of frozen contamination
- Detection threshold: 0.1 to 0.25 mm

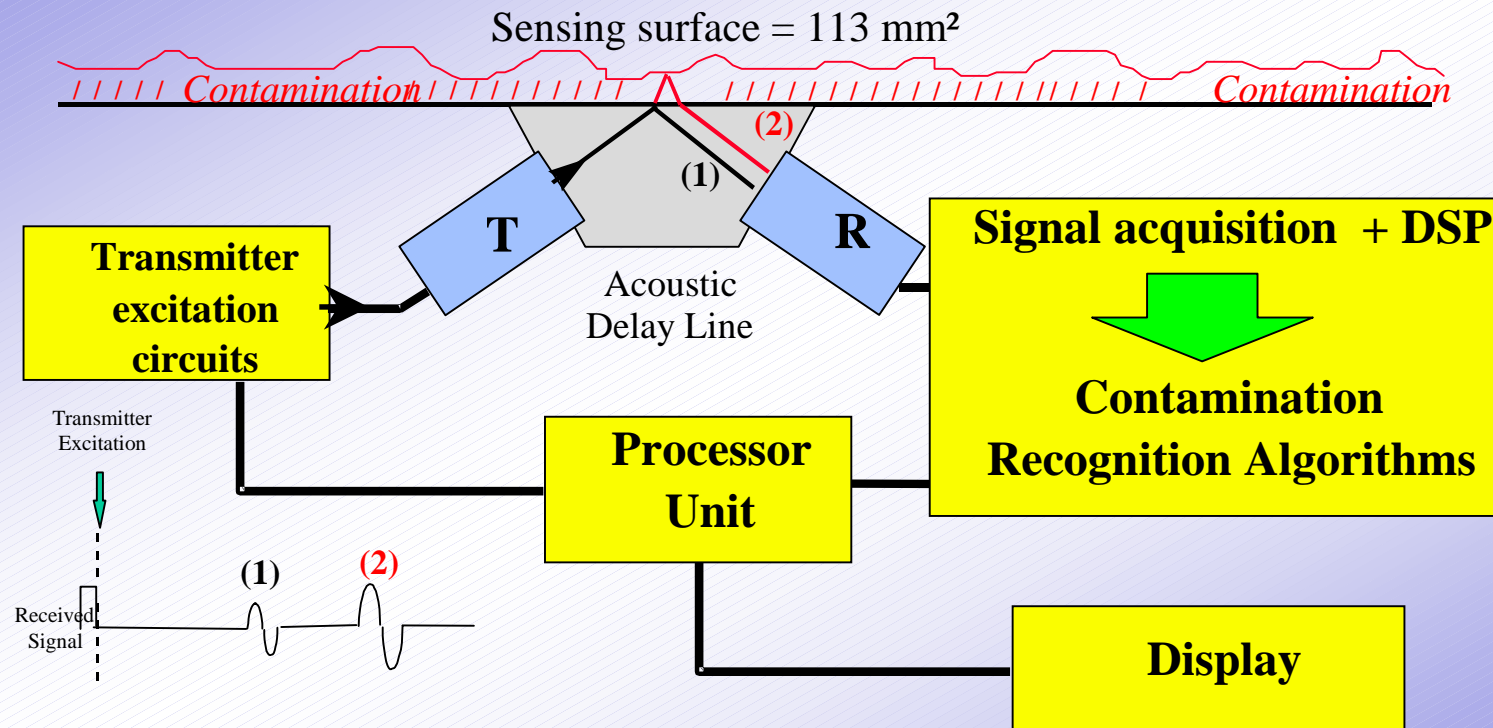


■ Technology based on acoustic impedance measurements.

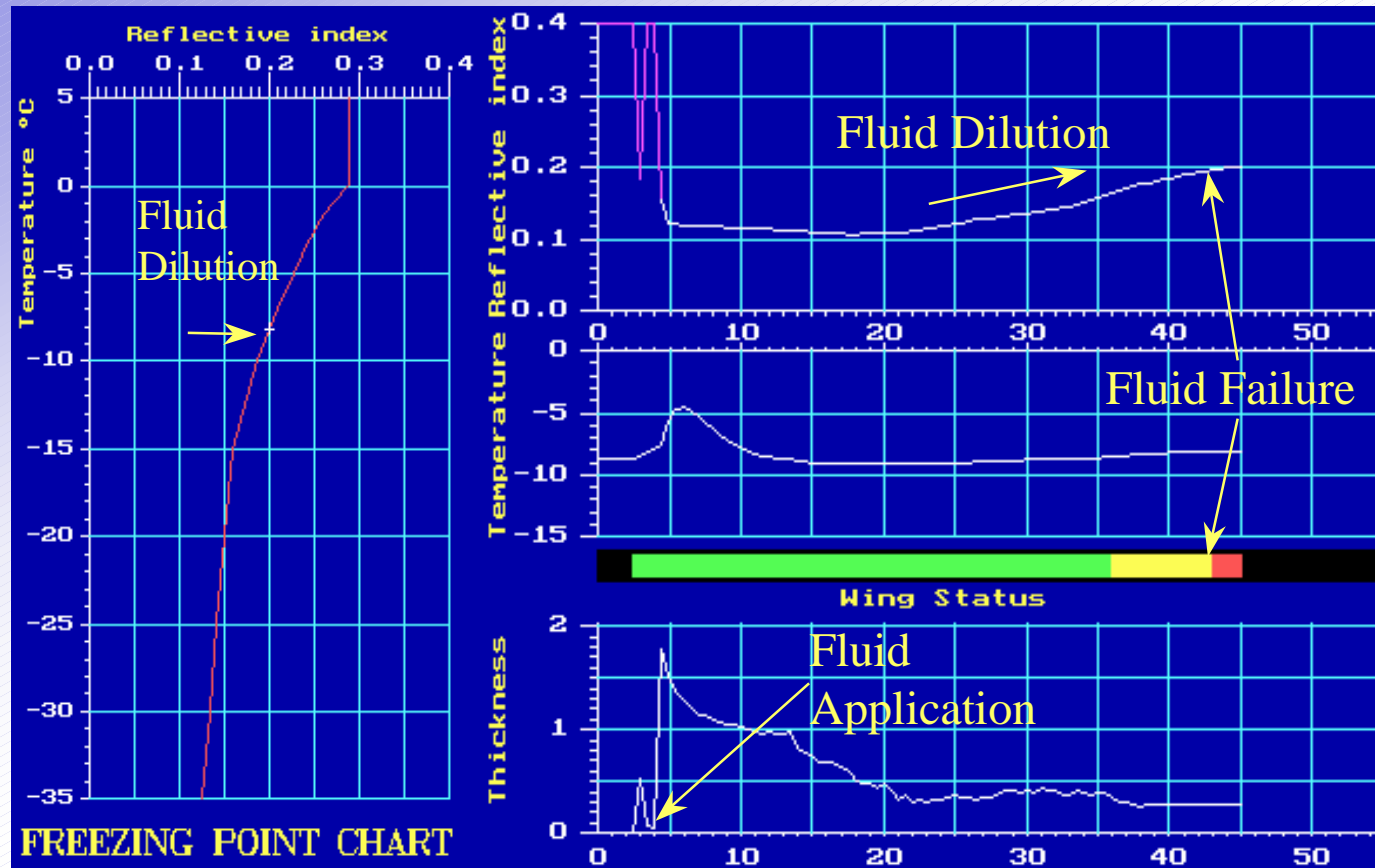
- Use Point Sensors or arrays of point sensors.



Theory of Operations



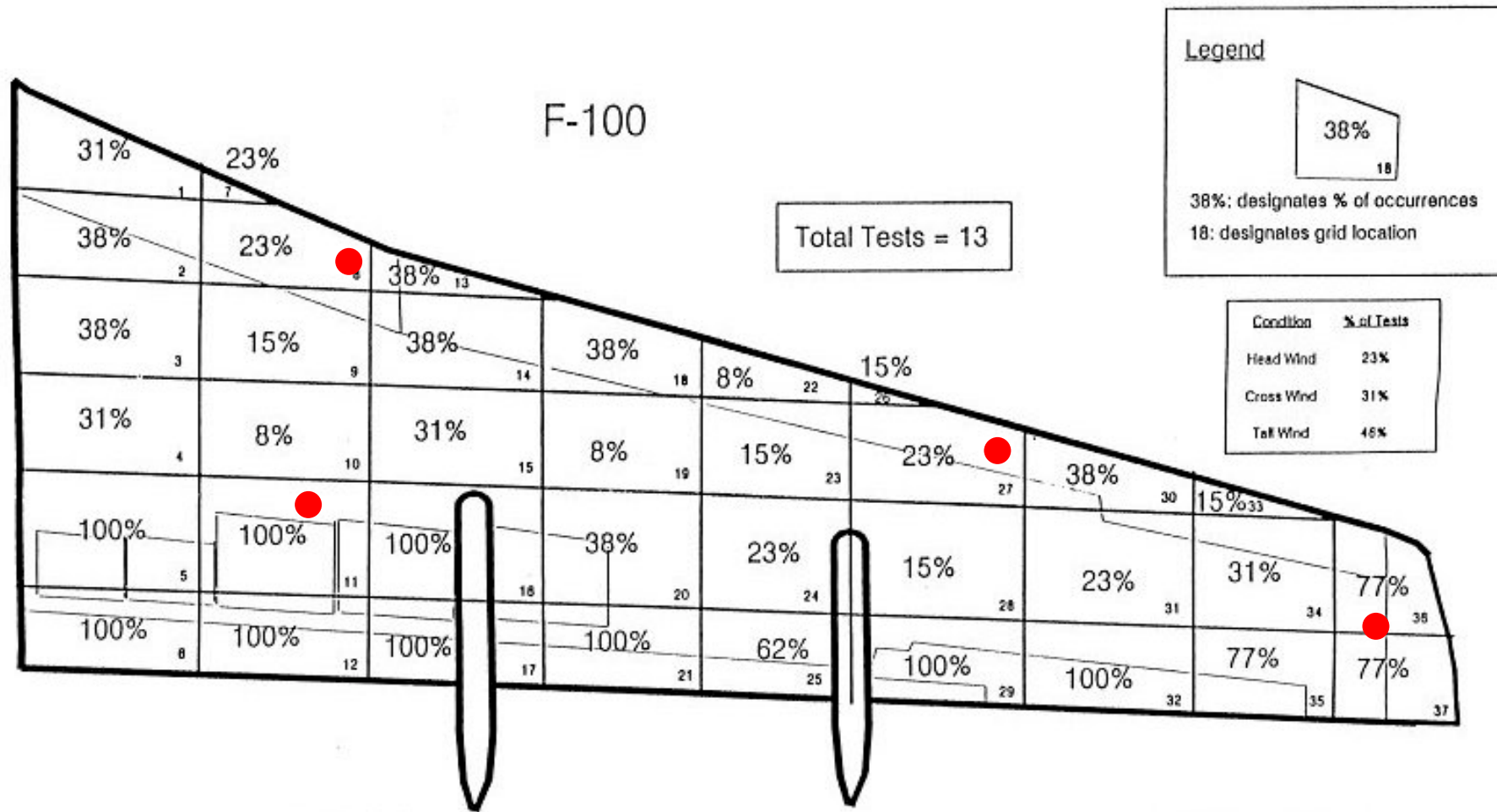
Fluid Condition Monitoring



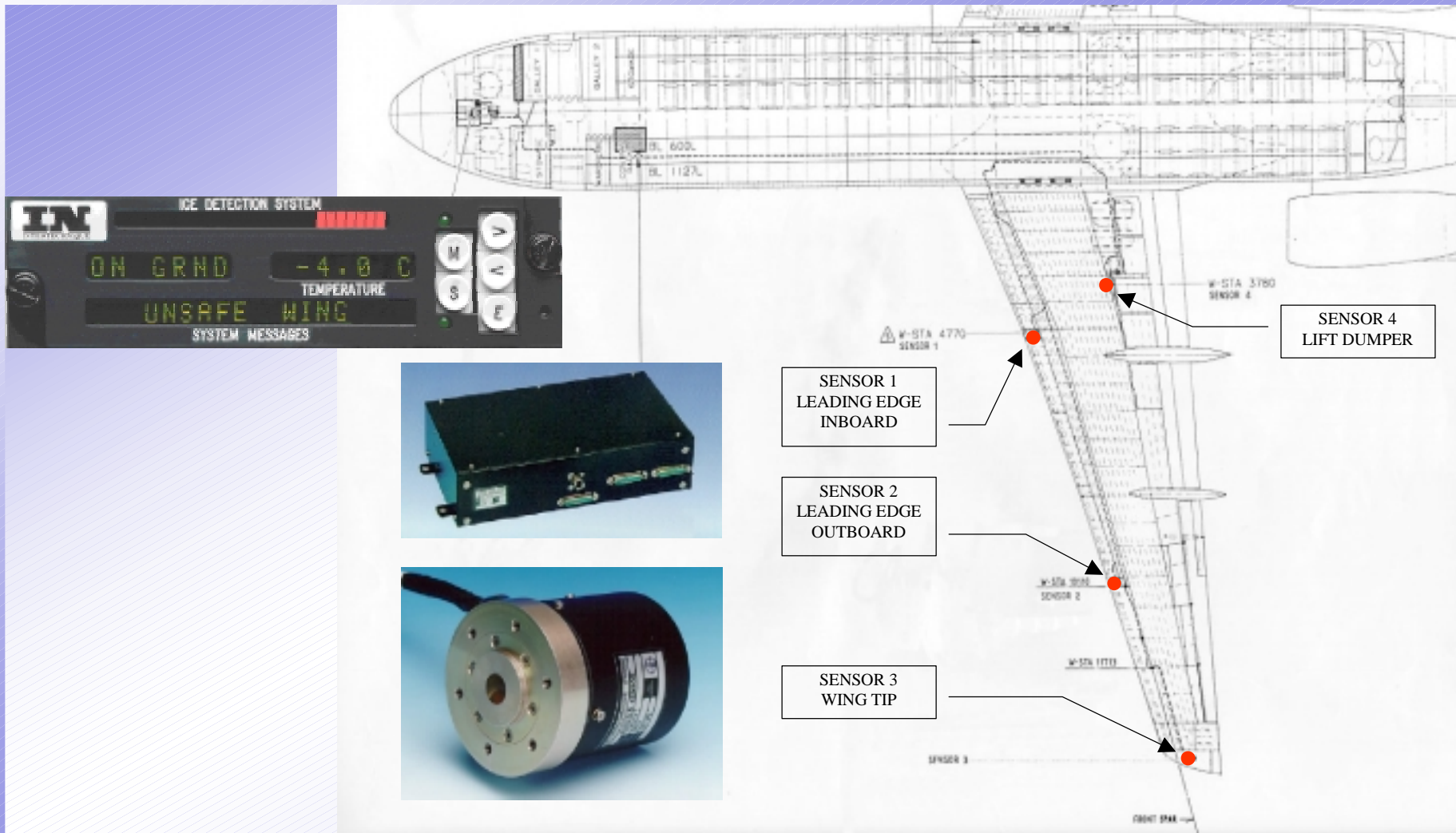
Note: Fluid tests performed on a standard flat plate inclined at 10°, the parameters are measured at 150mm from the upper edge.



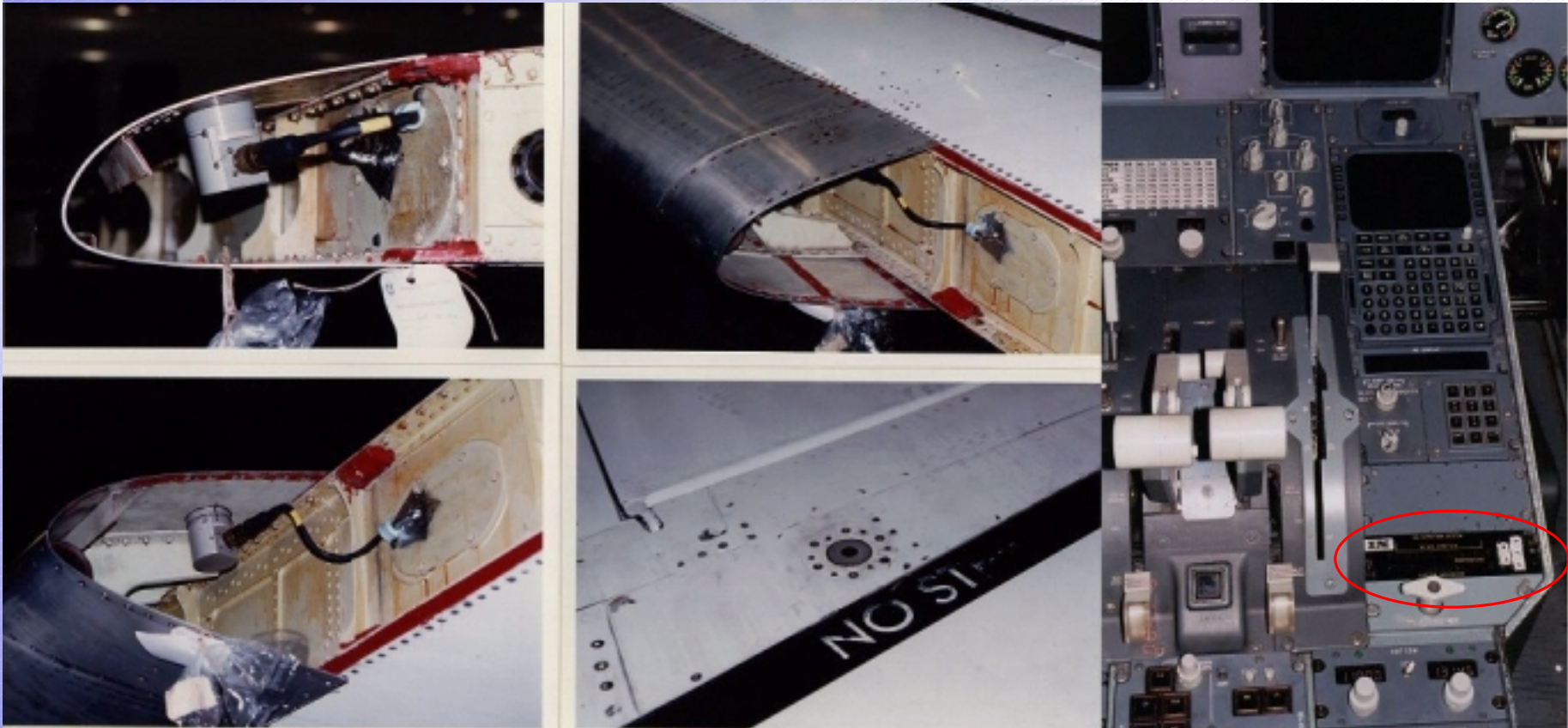
Sensors Positioning



Installation on Fokker 100 operated by TRANSWEDE / BRAATHENS



Installation on Fokker 100



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INTERTECHNIQUE

Objectives of the Evaluation

- Confirm the performances of the system obtained during the environmental tests on flat plates done by AMIL.
- Alternative to the tactile inspection required after deicing ?
 - Demonstrate the capabilities of the system to detect the presence of frozen contaminations after deicing.
- Alternative to the HOT tables ? Contamination Checks ? Pre-takeoff Contamination checks ?
 - Demonstrate the capabilities to provide reliable information about the anti-icing fluid effectiveness. Validate the sensors positionning.
- Get an operational feedback from the crews.

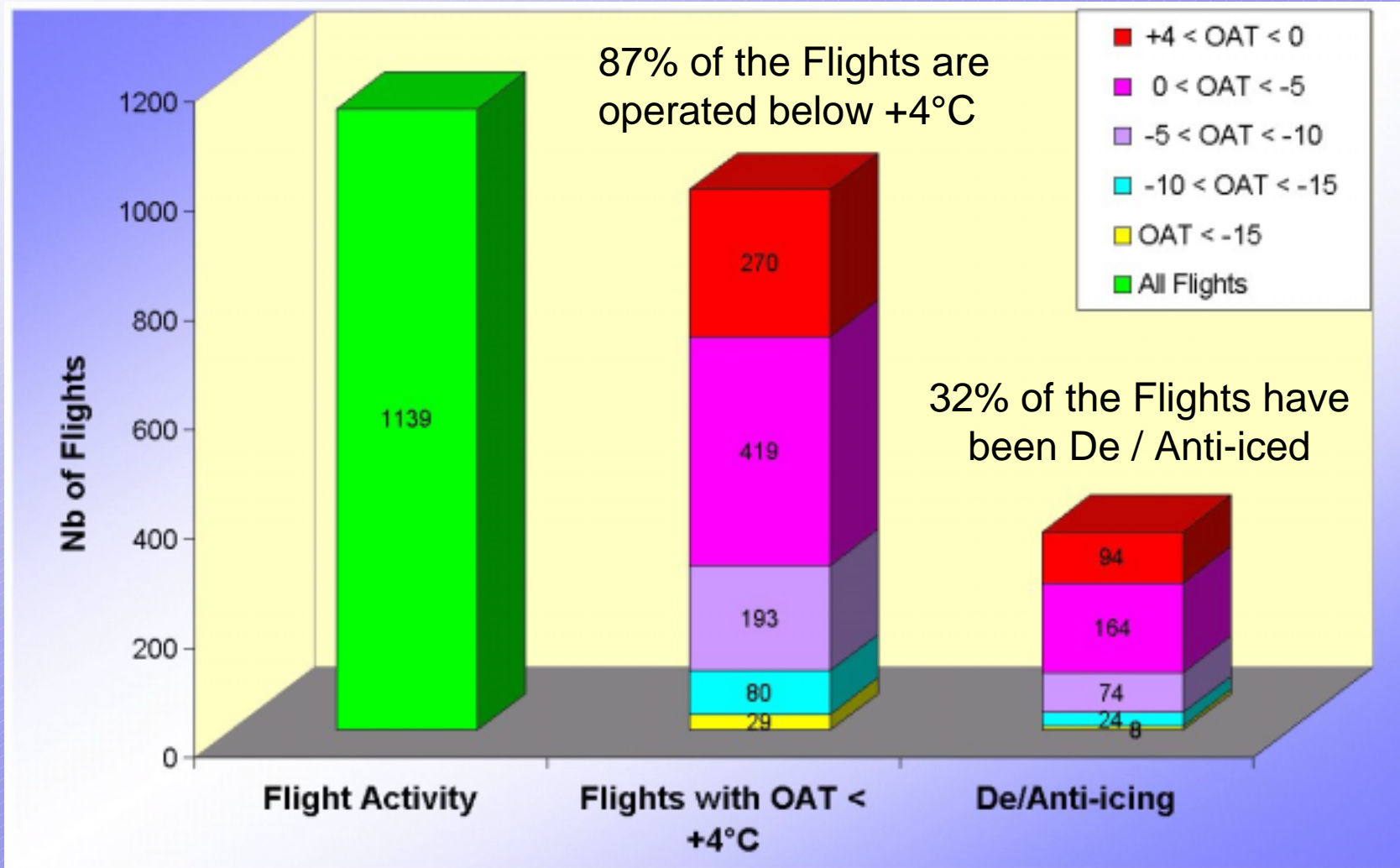


System Evaluation Tools

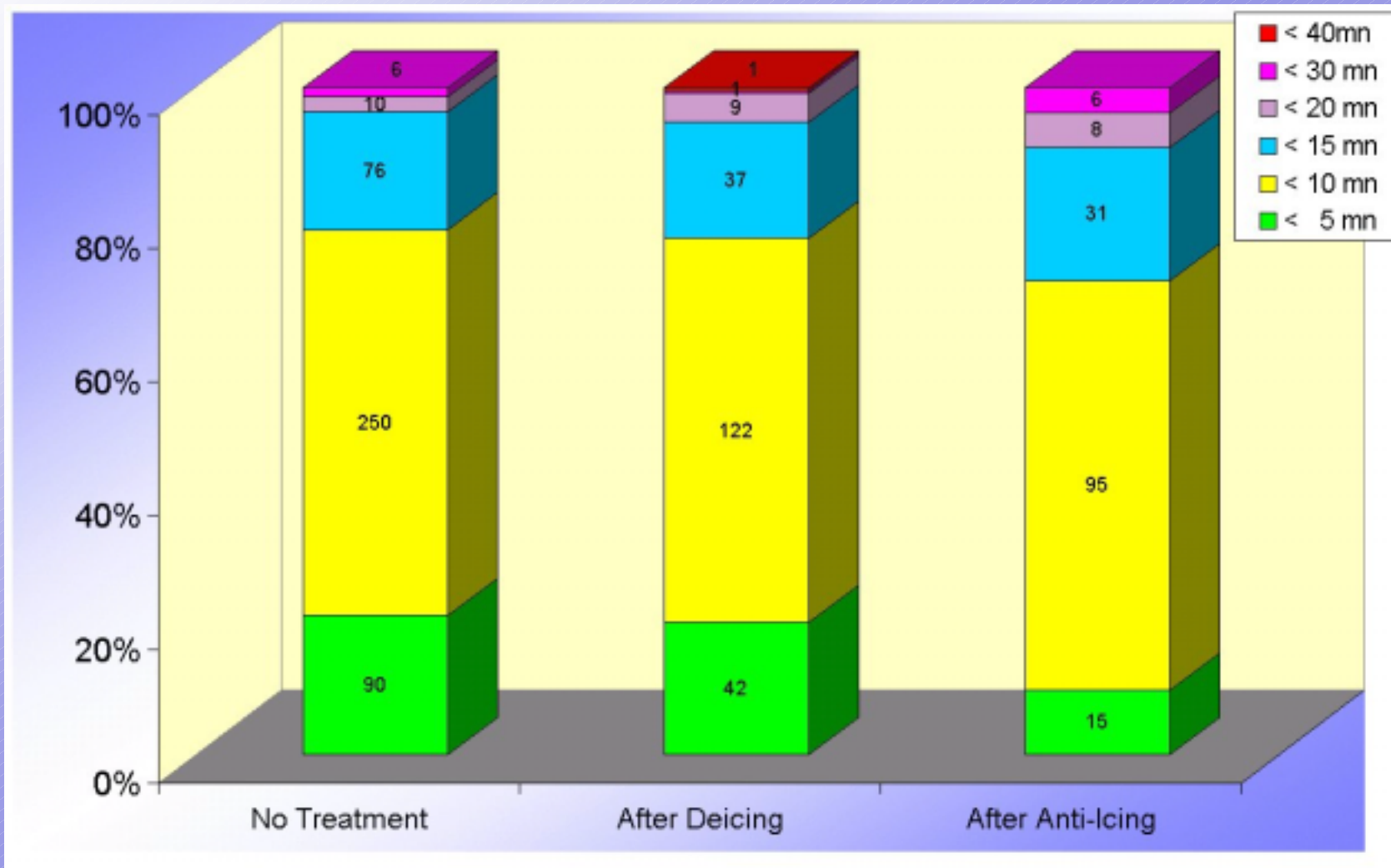
- Automatic data recording at each TO, if OAT < +4°C or if any warning is raised by the system. (6000 files)
- Flights on the cockpit jump seat for system behaviour observation (about 100 flights).
- System evaluation by the Crews.
- Overnight tests in icing conditions.



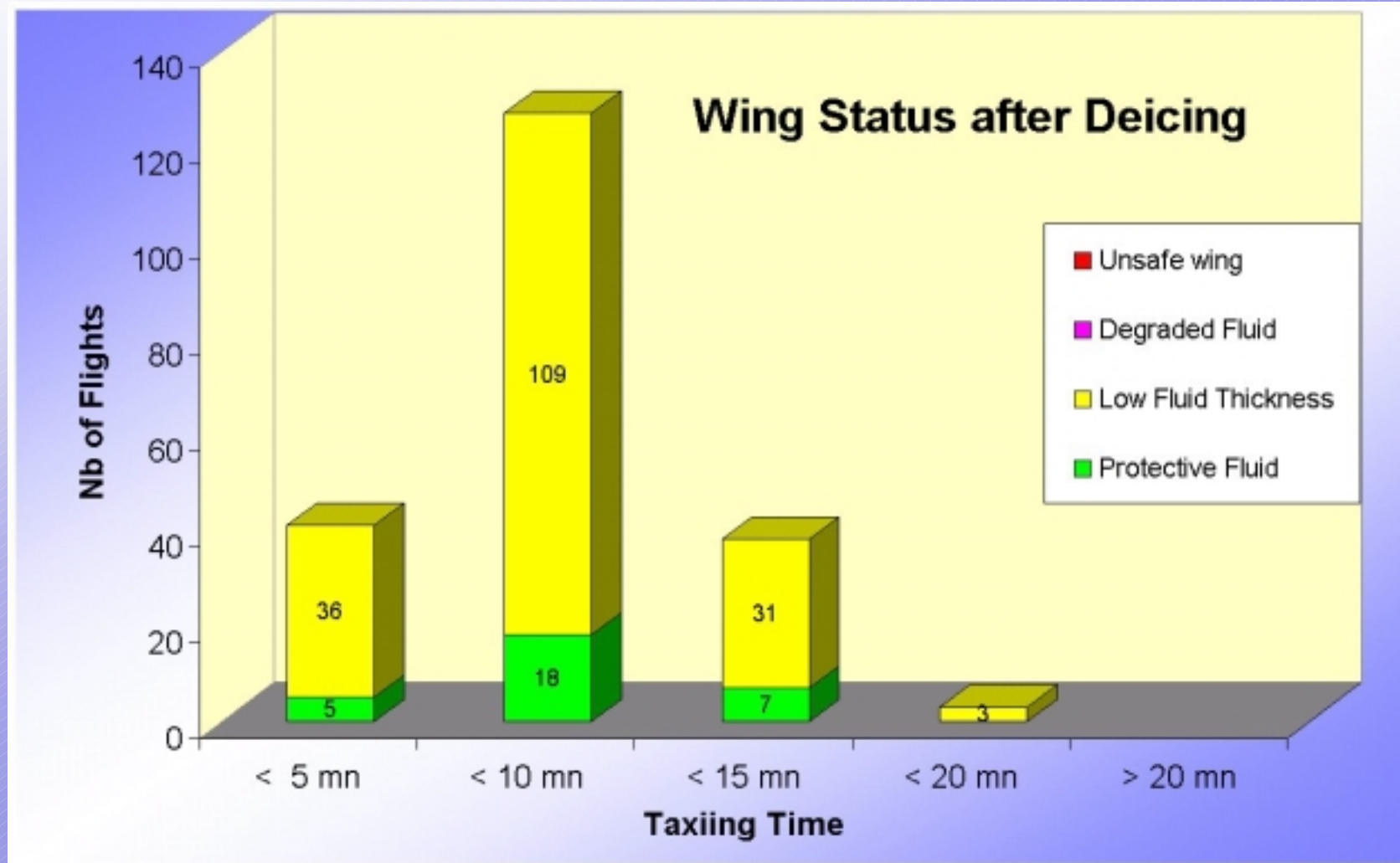
Recorded Airplane Activities, Dec 97 – Jan 2000



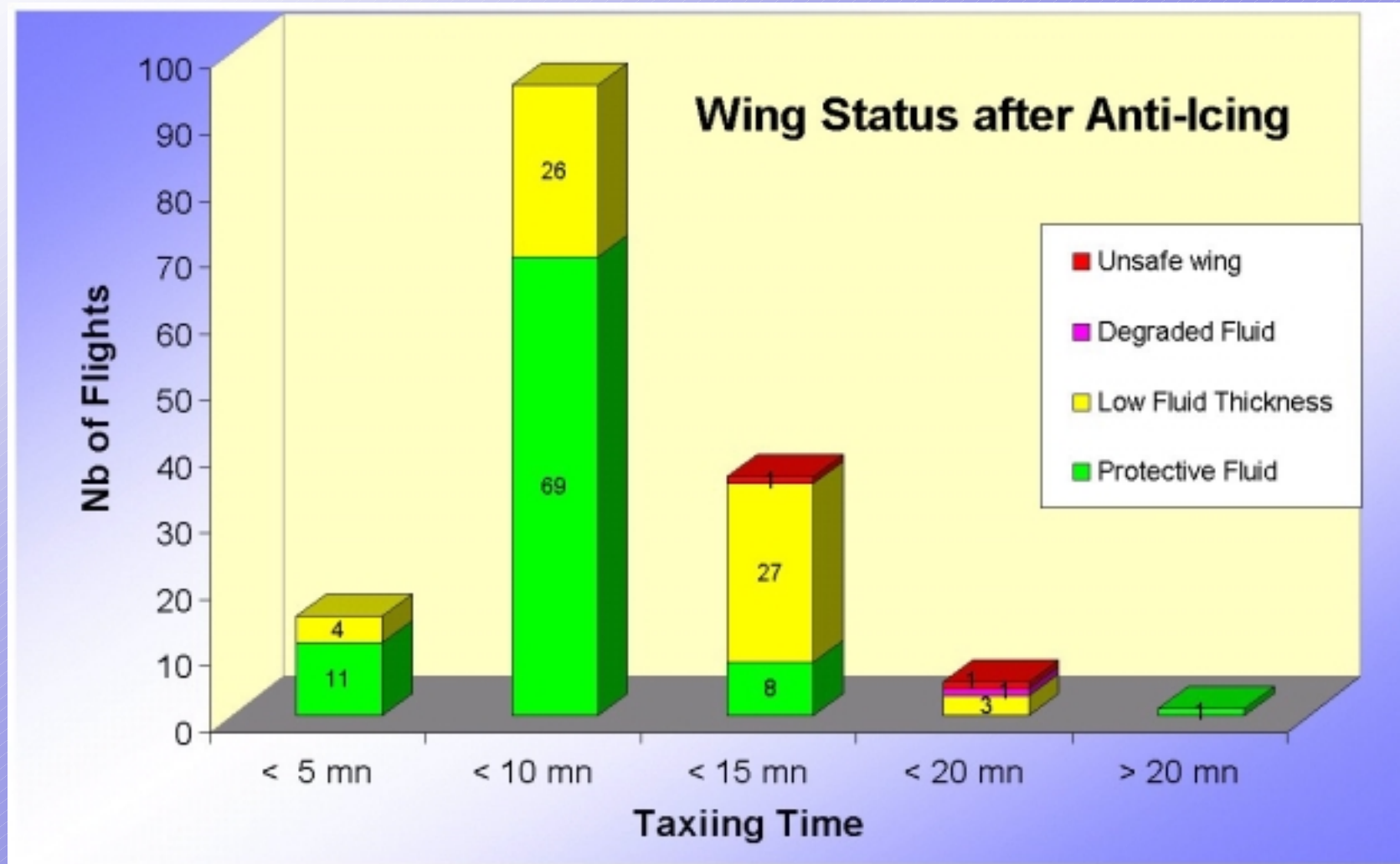
Taxiing Time



Wing Status after Deicing vs Taxiing Time

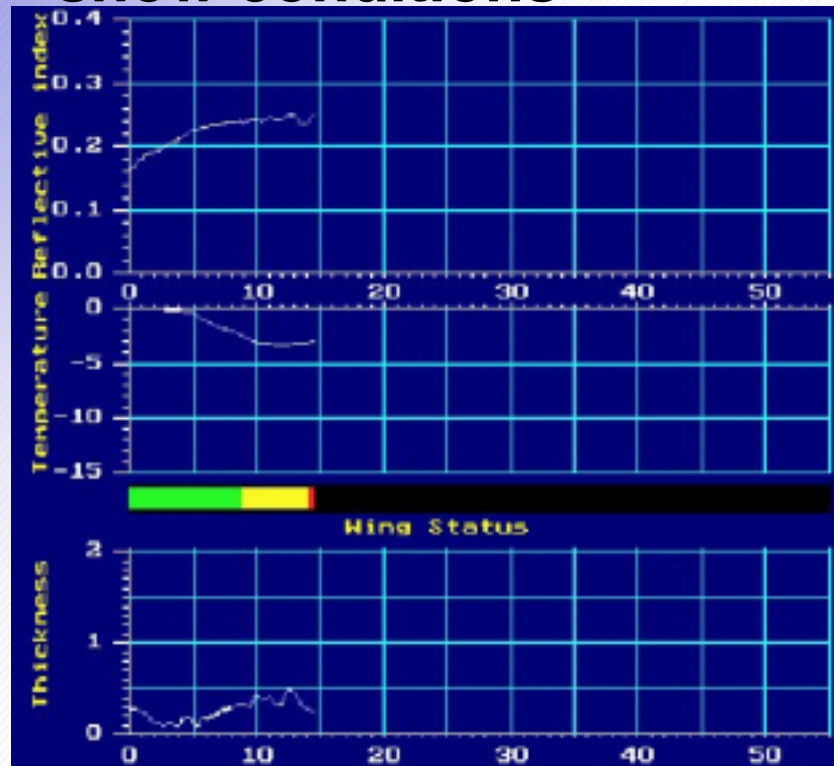


Wing Status after Anti-Icing vs Taxiing Time



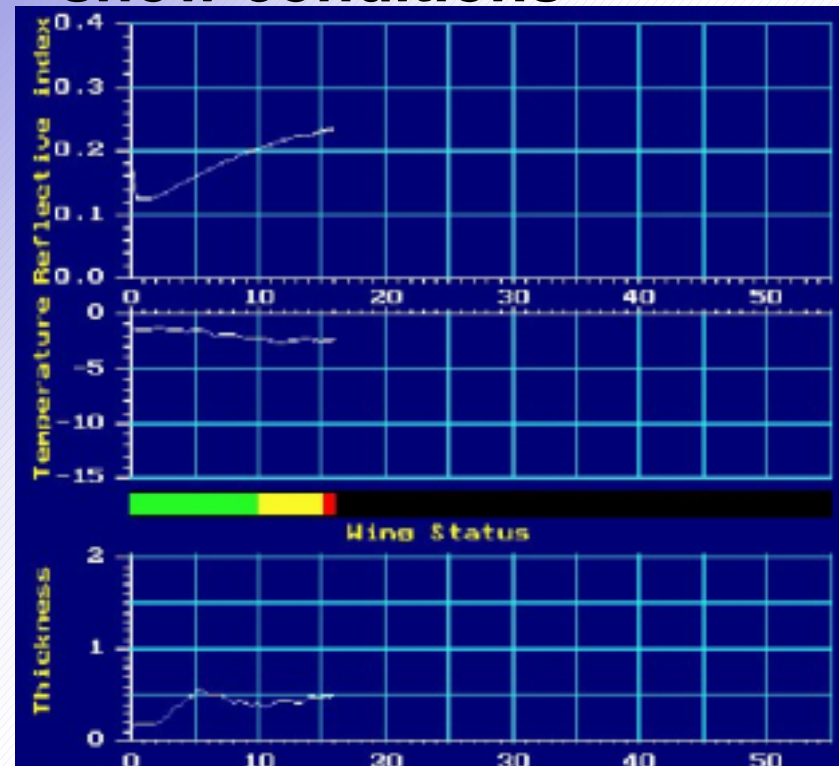
Wing Status after Fluid Failure

- **Unsafe Wing** Indication after 14 mn Taxiing under snow conditions



WING TIP

- **Unsafe Wing** Indication after 16mn Taxiing under snow conditions



TRAILING EDGE



Risk to Take Off with contamination on the wing

→ RISK OF FLUID FAILURE ON SMALL AIRPORTS

Taxiing Time	FLUID USED	
	TYPE IV Fluid	TYPE II Fluid
> 10 min	No Data	No Data
< 10 min	< 1%	No Data

→ RISK OF FLUID FAILURE ON LARGE AIRPORTS

Taxiing Time	FLUID USED	
	TYPE IV Fluid	TYPE II Fluid
> 25 min	No Data	N/A
> 10 min	< 2%	<11%
< 10 min	< 1%	3%



Ice Detection Summary

On Ground Ice Detection Summary

- **Before wing treatment (at the gate).**
 - **85 detections of Snow, Frost or Ice.**
- **After wing treatment (during taxiing).**
 - **2 fluid failure detection after 14 and 16 minutes.**
 - **1 degraded fluid warning after 18 minutes.**

In Flight Ice Detection Summary

- **Over the 1450 recorded flights, 183 in flight icing events have been detected.**



PILOTS REPORTS

REPORT CATEGORIES

Weather and Wing Treatment Report	25	
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Reasons

Unexpected	Unsafe Wing during taxiing Report	5	Alarm not reseted by the crew after deicing
Confirmed	Unsafe Wing during taxiing Report	2	

Unconfirmed	In Flight Icing Report	0	
Confirmed	In Flight Icing Report	3	

Reasons

Undetected	Contamination at the gate Report	4	Hoarfrost and dry snow not detected at the gate
Detected	Contamination at the gate Report	4	

Reasons

System Failure report	5	Sensor 4 failure in January 99 (Elect. Comp. Failure)
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Total: 48 Reports



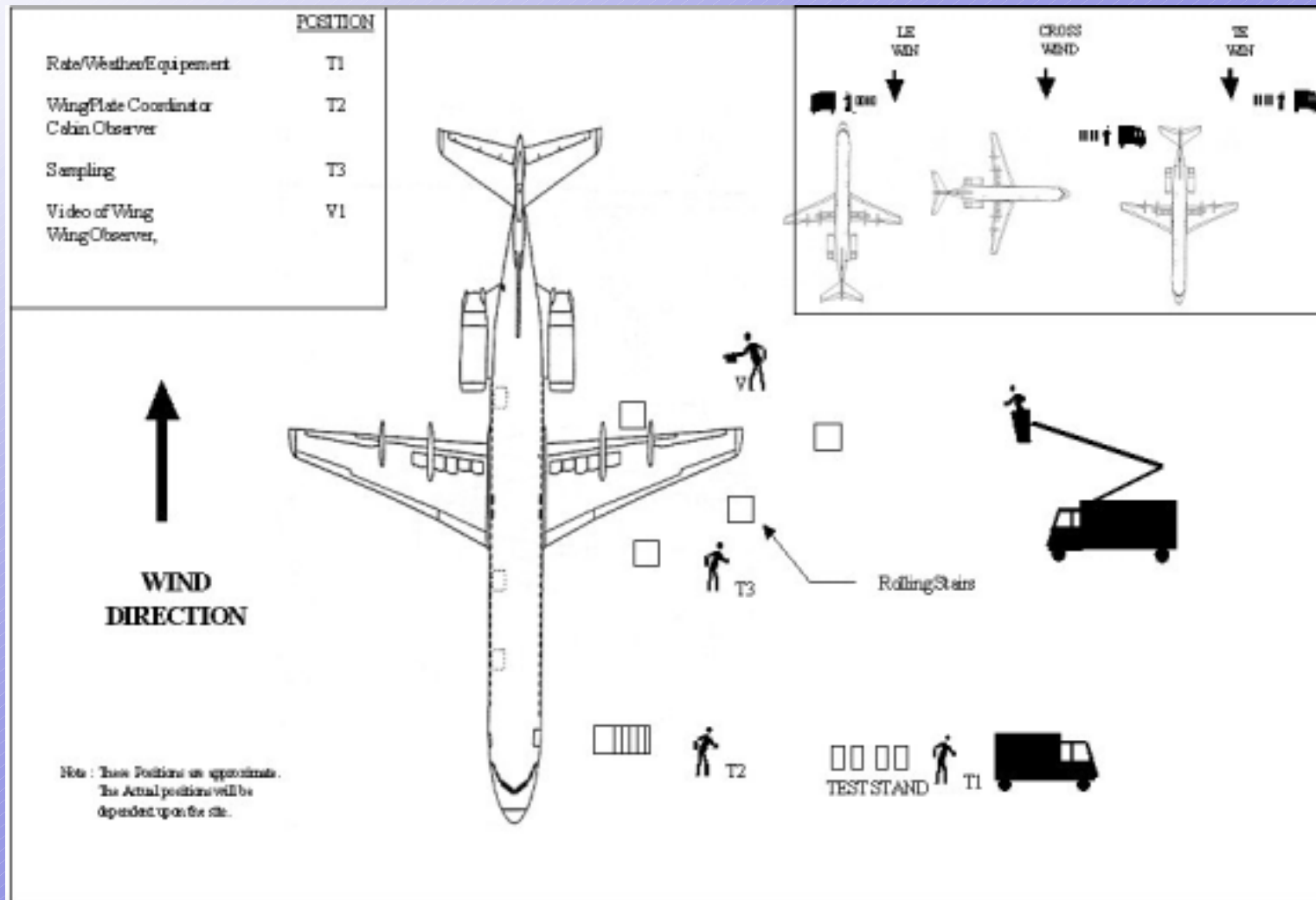
OVERNIGHT TESTS



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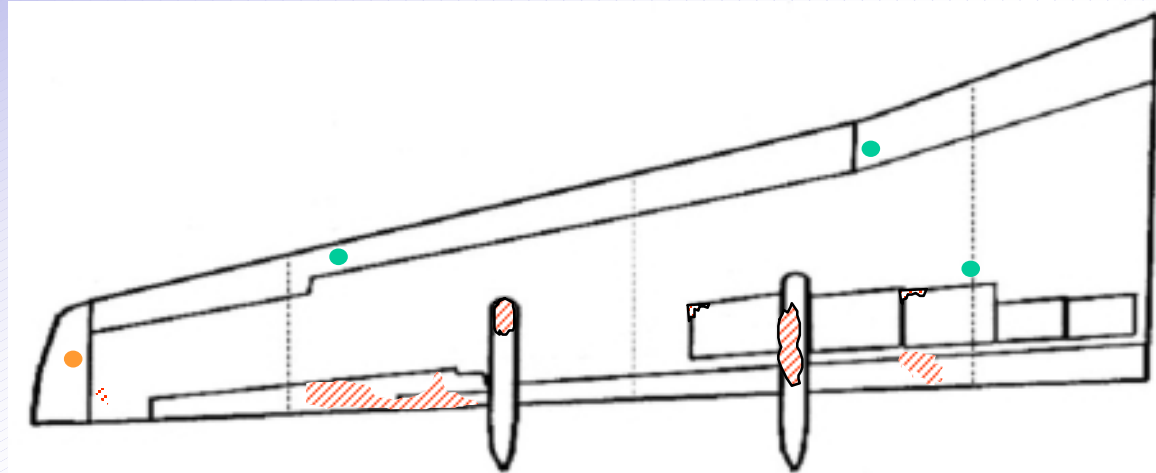
Overnight Test Setup



Typical Overnight Test Result

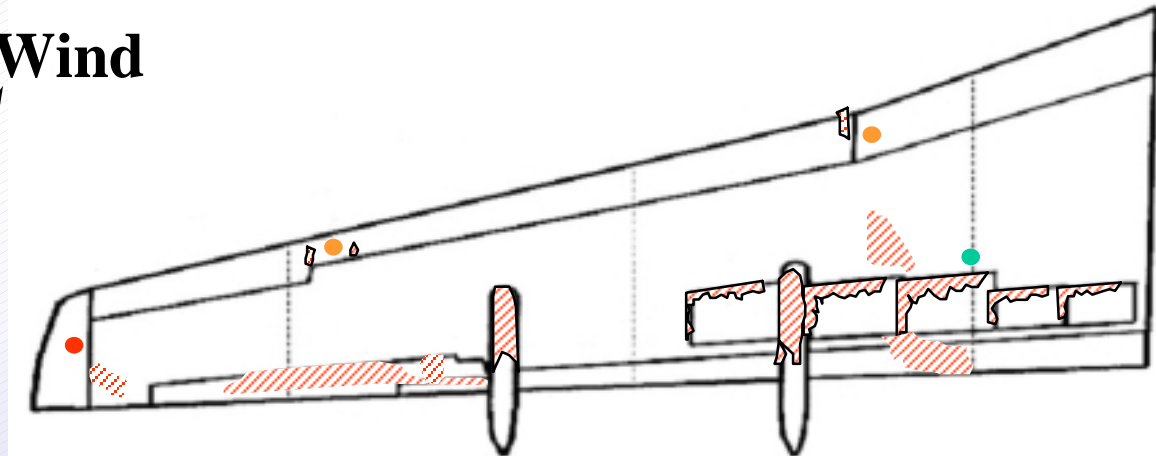
- TYPE IV Fluid Failure Patterns / System Indications.

- After 20 minutes
DEGRADED FLUID



- After 40 minutes
UNSAFE WING

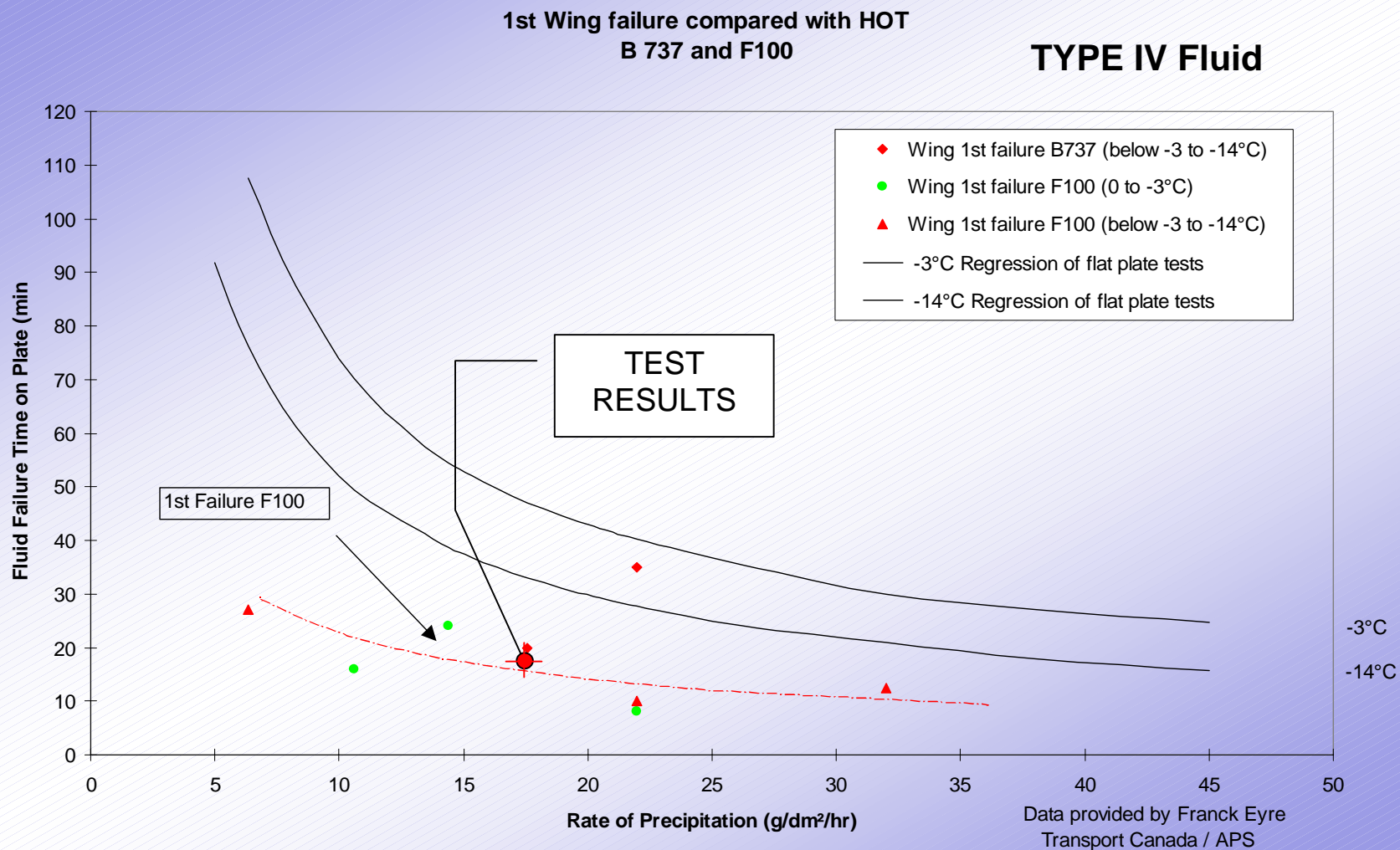
Wind
↓



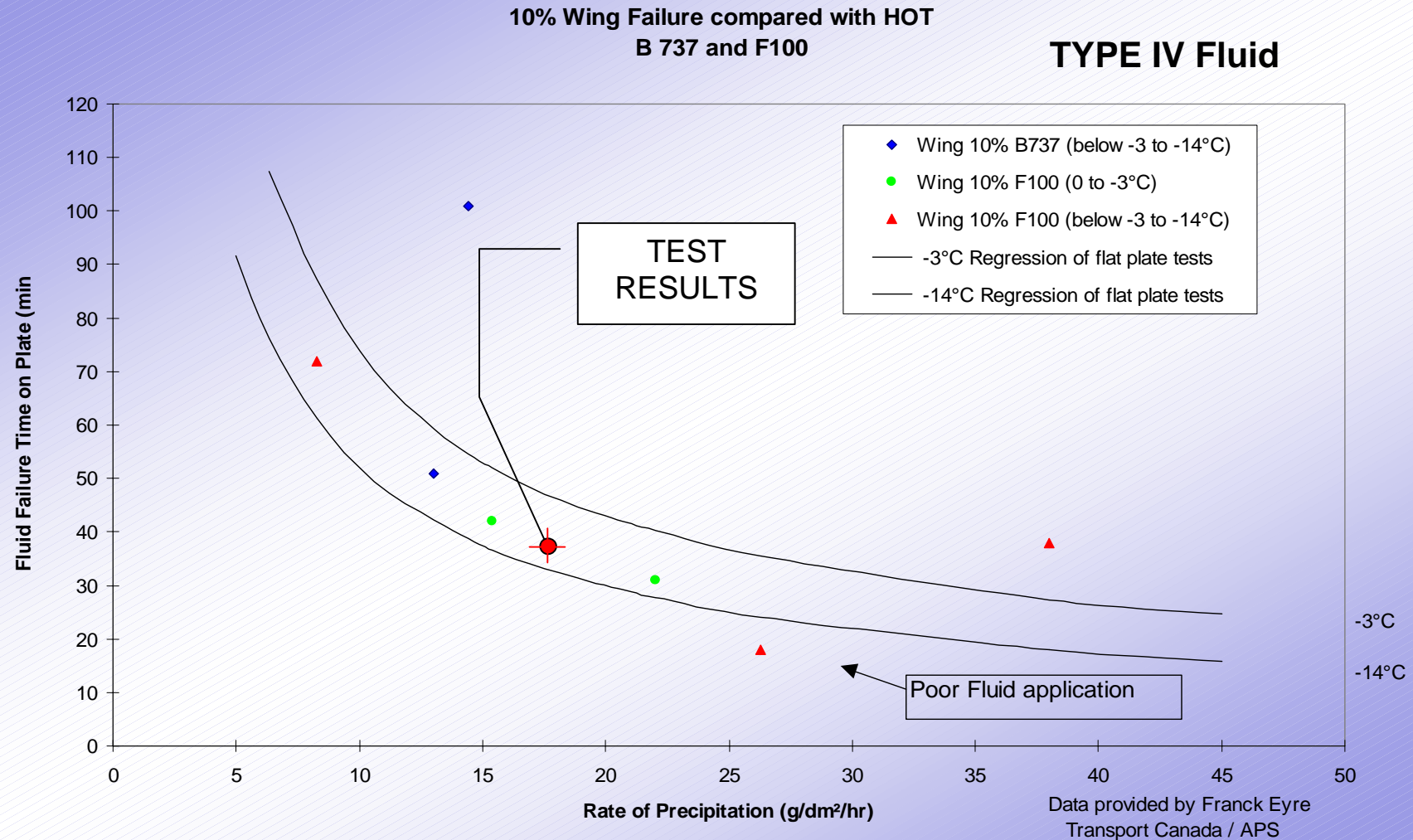
OAT -2.5 °C very wet snow
(Moderate)
Expected HOT 35 / 60mn



1st Wing Failure compared with HOT



10% Wing Failure compared with HOT



Conclusions

- Use of in-situ spot sensors for pre-deicing wing inspection does not seem to be appropriate (too limited representativity)
- When aircraft wings have been treated, the fluid monitoring in-situ spot sensors provide accurate indications on the effectiveness of the anti-icing treatment.
- During A/C operations and the overnight tests, the system indications were well correlated with the overall wing contamination, confirming the correctness of the sensors positionning over the wing.
 - ➔ The system provides the capability to replace HOT guideline tables and to assist the PIC in making his decision for contamination check and/or pre-takeoff contamination check. (First step as Advisory)

